Status of the Landsat Data Continuity Mission

presented by

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at the

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Landsat 7 Status

- **Landsat 7 and its Enhanced Thematic Mapper-Plus (ETM+) sensor reach the end of its five-year design life on April 15, 2004**
- **ETM+ scan line corrector (SLC) anomaly occurred on May 31, 2003**
  - Only center third of each ETM+ scene unimpaired by gaps (see next slide)
- **One of three attitude control gyros was shut down in May 2004 with no adverse impacts on image acquisition or data quality**
  - Probabilistic risk assessment conducted for failure of a second gyro
  - The probability of continuing the mission beyond 2007 is less than 10%
- **Fuel depleted in 2011**
- **ETM+ data quality remains high**
  - Radiometric and geolocation accuracies have not been affected by the SLC anomaly and gyro failure
- **The USGS EROS Data Center is offering "gap-filled" composite products that mitigate the impact of the SLC anomaly**
  - Gap-filled products offered at a reduced price ($275 per scene) beginning May 10, 2004

Impact of the ETM+ SLC Anomaly

PRE-SLC FAILURE

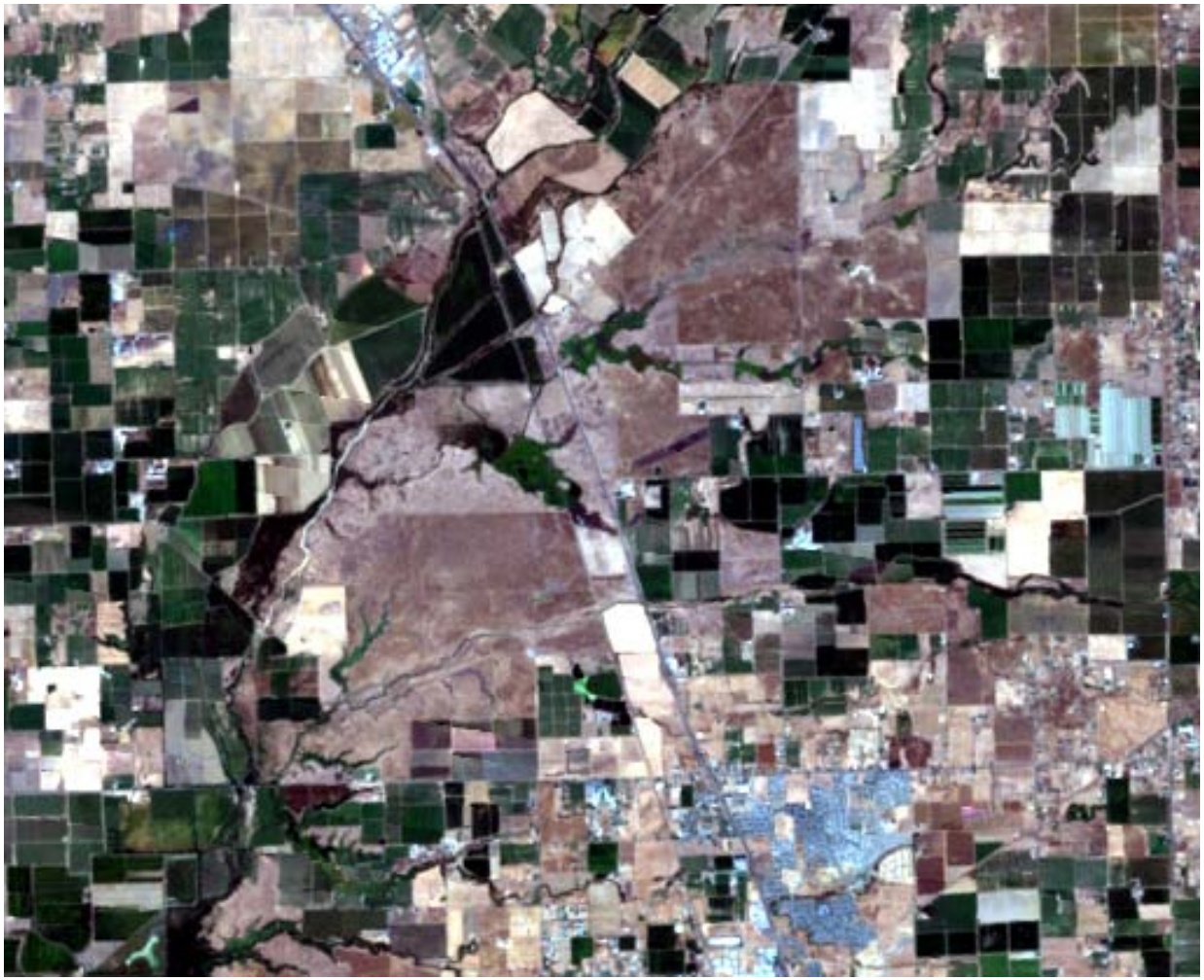
3 MARCH 2000

POST-SLC FAILURE

20 SEPTEMBER 2003

Note that the images show partial scenes

ETM+ Gap-Filled Data Product (Tahoe, NV)



Landsat 5 Status

- **Landsat 5 and its Thematic Mapper (TM) sensor are 20 YEARS OLD, 17 years past 3-year design life**
  - Satellite is only capable of the direct transmission of data in real time
    - TDRSS antenna transmitter failed in 1992; no onboard data recorder
    - EROS Data Center directly receives data only for CONUS
  - TM data are directly transmitted to a growing number of International Ground Stations (IGS's) since the Landsat 7 SLC anomaly
    - Only the Australian IGS sends tapes to the EROS Data Center
  - No redundancy remains: TM scan mirror operates in back-up "bumper mode"; battery performance at margin; down to last X-band transmitter, reaction wheel, thruster
  - Fuel depleted in Fall, 2008

LDCM Background

- **NASA and the DOI/USGS initially planned to implement a Landsat Data Continuity Mission (LDCM) by procuring data from a privately owned and commercially operated remote sensing system**
  - In accordance with Congressional guidance and the Land Remote Sensing Policy Act of 1992 (PL 102-555), the Commercial Space Act of 1998 (PL 105-303), and the U.S. Commercial Remote Sensing Policy (April 25, 2003)

- **NASA and the USGS initiated a two-step approach towards a partnership between government and industry**
  - The first step was a formulation phase with multiple contractors
  - An implementation phase was planned as the second step
    - NASA planned to award a single contract for the acquisition and delivery of specification-compliant LDCM data for a five-year period (with a costed option for an additional five years)

LDCM Background (cont.)

- **The first-step formulation phase was completed**
  - An RFP for formulation studies was released in Nov., 2001
    - Called for the formulation of preliminary system designs
  - Two firm fixed-price contracts ($5M each) were awarded in March, 2002
    - Resource 21 of Englewood, CO
    - DigitalGlobe of Longmont, CO
  - Formulation culminated with preliminary design reviews in Nov., 2002

- **The implementation phase was cancelled**
  - An implementation phase RFP was released Jan. 06, 2003; proposal deadline was Feb. 25, 2003
  - NASA declined to accept any offers and **cancelled the RFP in September, 2003** following an evaluation of proposals
  - NASA concluded that the response to the RFP failed to meet a key objective and expectation of the planned implementation, namely to form a fair and equitable partnership between government and industry

EOP Working Group

- **The Executive Office of the President (EOP) formed an LDCM interagency working group following the RFP cancellation**
  - The U.S. Director of Space Policy in the NSC directed the working group in consultation with the OSTP and the OMB
  - Representatives from NASA, DOC/NOAA, DOI/USGS, NGA, and NRO participated

- **Working group deliberations led to the release of a "Landsat Data Continuity Strategy" memorandum**
  - Signed by the President's Science Advisor, Dr. John Marburger, III, on August 13
  - The memo can be found on NASA's LDCM web site:

http:// ldcm.gsfc.gov

Marburger Memorandum

- The memorandum states that "the Departments of Defense, the Interior, and Commerce and the National Aeronautics and Space Administration have agreed to take the following actions:
  - "Transition Landsat measurements to an operational environment through the **incorporation of Landsat-type sensors on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) platform** …
  - "Plan to **incorporate a Landsat imager on the first NPOESS spacecraft (known as C-1), currently scheduled for launch in late 2009 …**
  - "**Further assess options** to mitigate the risks to data continuity prior to the first NPOESS-Landsat mission, **including a "bridge" mission."**

Marburger Memorandum (cont.)

- The memorandum further states that:

"This NPOESS-Landsat operational strategy will need to be **justified through the normal budget process**. Implementation will be **subject to the availability of appropriations**, other applicable laws, and Presidential guidance. **The cost sharing requirements of the baseline NPOESS program do not apply**…"

Current Programmatic Direction

- **NASA GSFC expects direction to procure two Landsat sensors for flights on NPOESS satellites (C1 & C4)**

- **No current plans for a bridge or “gap-filler” Landsat mission**

NPOESS Background

- **NPOESS is the next generation operational environmental remote sensing system for the U.S.**
  - The nation currently operates two separate polar-orbiting environmental satellite systems
    - Defense Meteorological Satellite Program (DMSP)
    - Polar-orbiting Operational Environmental Satellite (POES) program
  - A 1994 Presidential Decision Directive instructed DoD and DOC to converge the two systems
- **An Integrated Program Office (IPO) manages NPOESS development**
  - DOC/NOAA interfaces to civil data users and will operate the NPOESS satellites
  - DoD supports major system acquisitions
  - NASA incorporates new technologies

NPOESS Background (cont.)

- **The NPOESS program will simultaneously operate three spacecraft when the system becomes fully operational in 2013.**
  - The first NPOESS satellite will launch no earlier than late 2009
  - The NPOESS program will build one replacement for each satellite extending operations to the end of the next decade
- **Each satellite will fly in a near-polar, 828 km-altitude orbit with a different equatorial crossing time: early morning, mid-morning, and afternoon**.
  - Only the mid-morning satellite is suitable for a Landsat sensor
- **The 828 km NPOESS orbit will change the Landsat ground track repeat period to 17 days**
  - Landsats 4, 5, and 7 were all launched into 705 km orbits with 16-day repeat periods
  - A new path/row reference system will be needed to catalogue Landsat data acquired from an NPOESS satellite (WRS-3)

NPOESS Background (cont.)

- Several of the following charts were extracted from material presented at the AMS Presidential Symposium on the Advances of Environmental Remote Sensing, January 13, 2004, in Seattle, WA

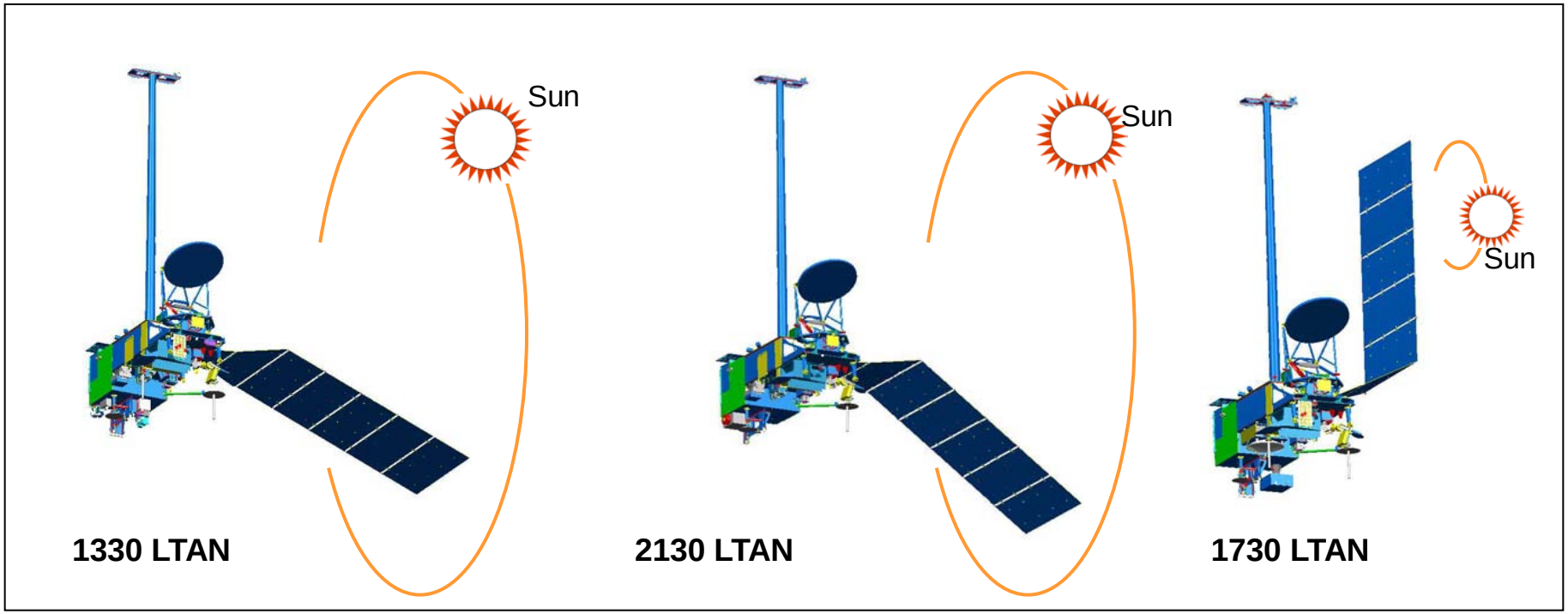
- These presentations can be found at the following URL

http://www.ipo.noaa.gov/News/Archive/2004/jan/01/page02.html

NPOESS Single Satellite Solution

LDCM

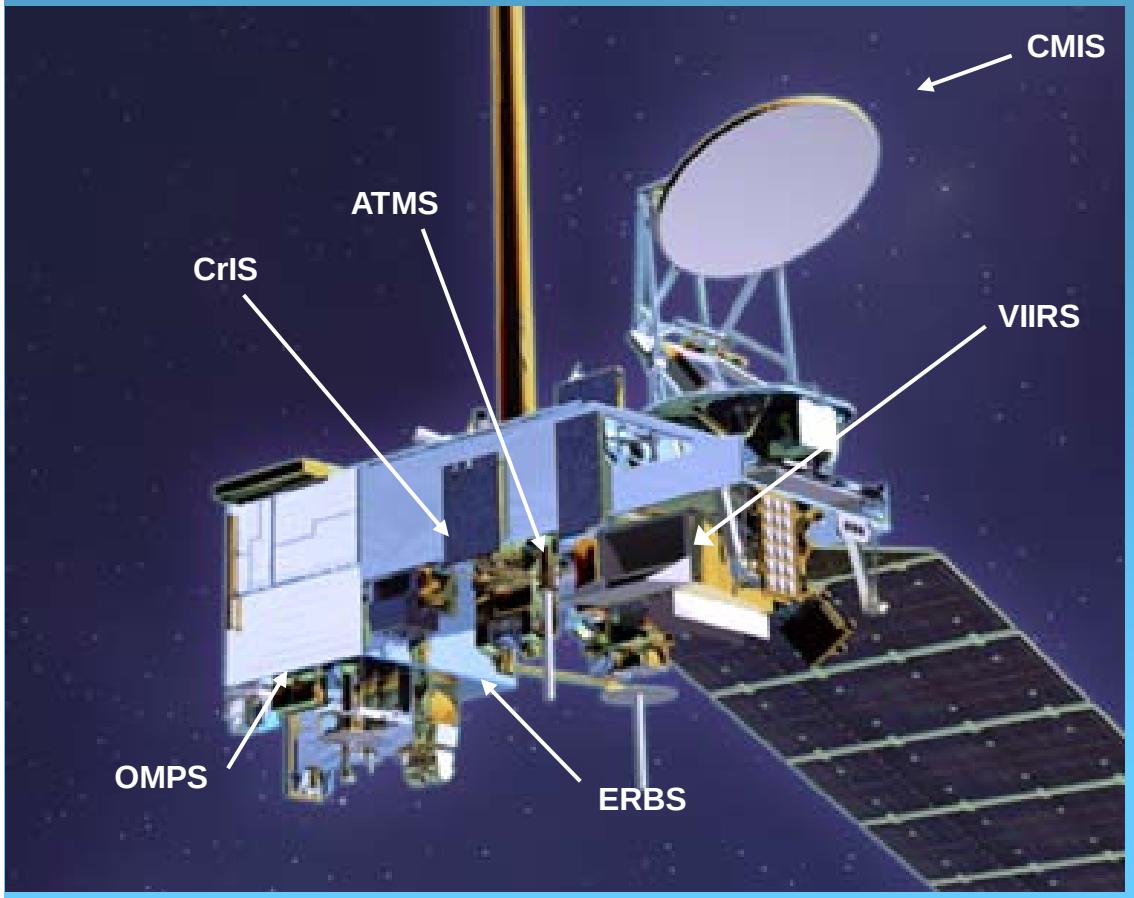
- Common spacecraft design for all three orbit planes
- Common sensors **in the same place** for efficient integration and re-configuration



- Only the 2130 “bird” suitable for Landsat sensor

NPOESS Satellite

LDCM



	1330	1730	2130
VIIRS	X	X	X
CMIS	X	X	X
CrIS	X	←	X
ATMS	X	←	X
SESS	X		
GPSOS	X		
OMPS	X		
ADCS	X	X	
SARSAT	X	X	X
ERBS	X		
SS	X	X	X
ALT		X	
TSIS		X	
APS			X

NPOESS 1330 Configuration

Single Satellite Design with Common Sensor Locations

NASA USGS

Potential Pre-planned Product Improvement (P3I)

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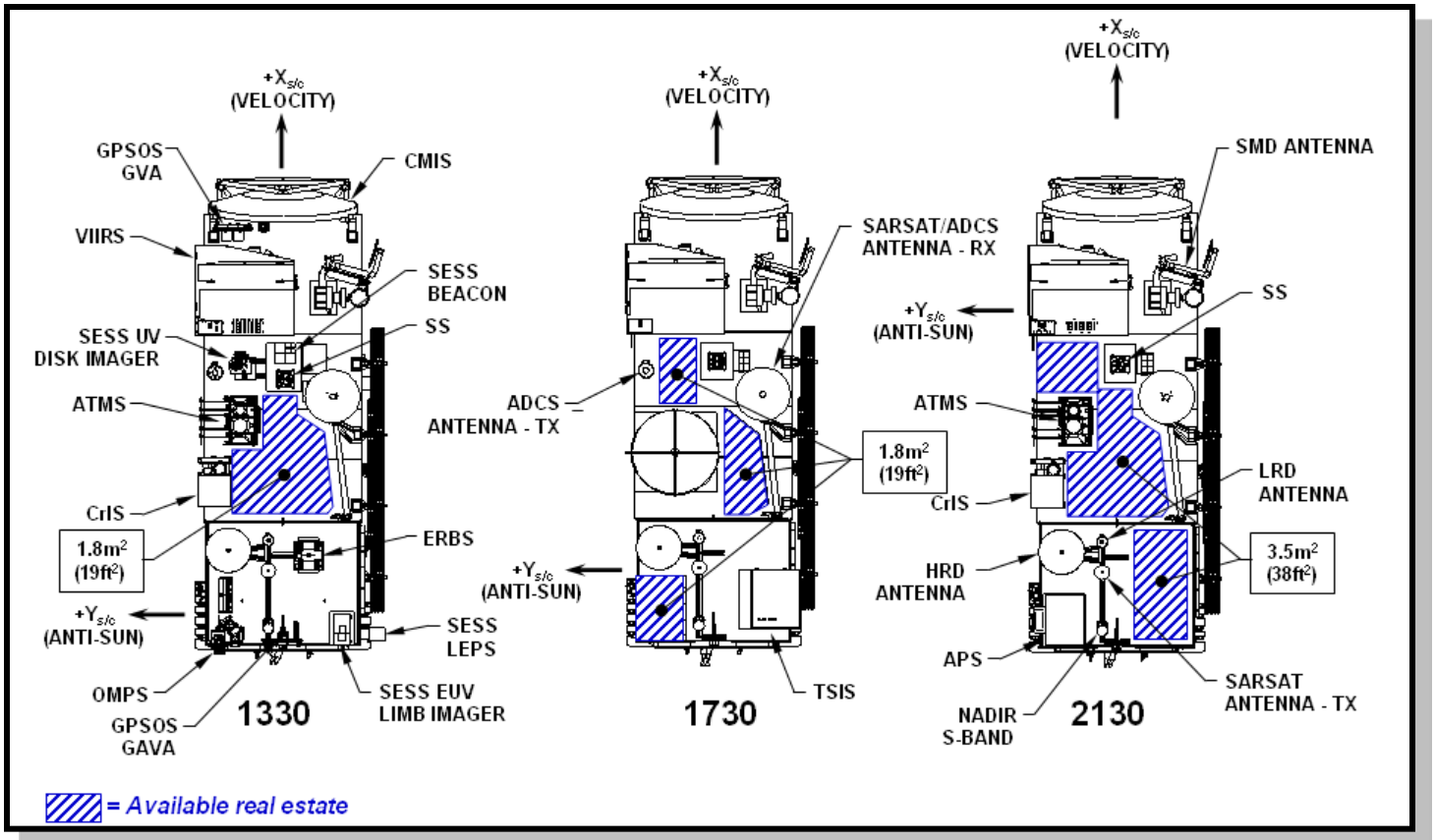
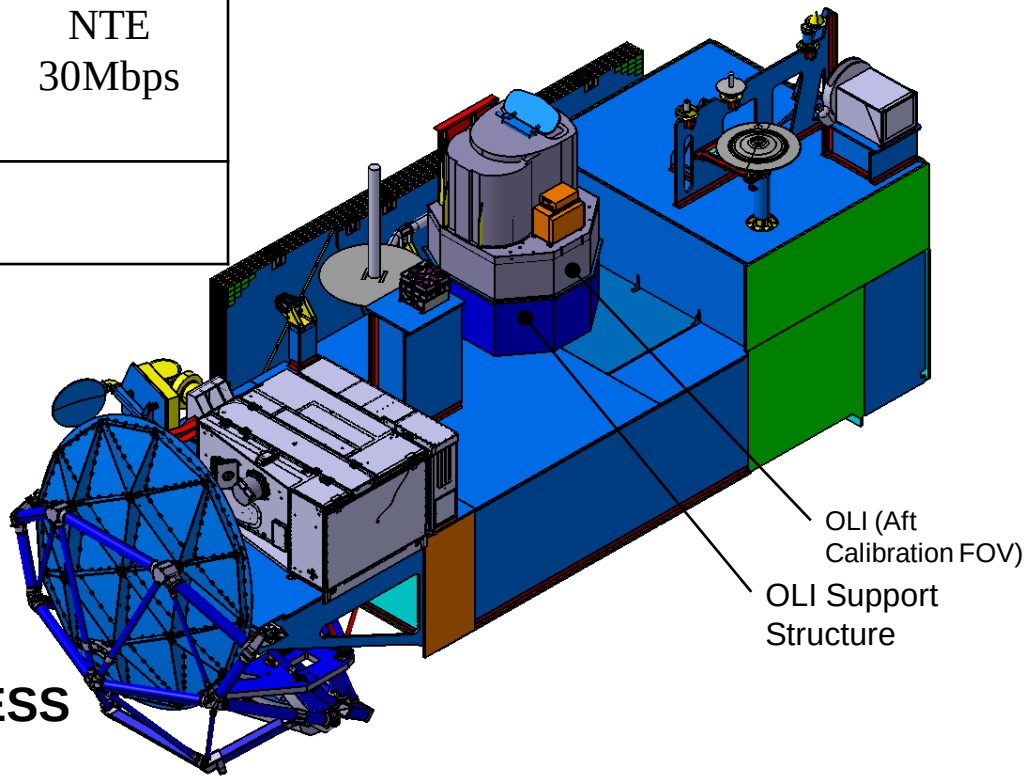
- The NPOESS space-craft is designed with a 25% margin for growth in space, mass, and power.
- Accommodation may be limited by Instrument Field of View (FOV) constraints.



Notional Landsat/NPOESS Interface Envelopes

LDCM

	Mass	Volume	Average Power	Data Rate / Volume
Reflective Band Sensor	200 kg	1.2x by 1.2y by 1.2z m	200 W	N/A
Solid State Recorder	50 kg	0.5x by 0.5y by 0.3z m	150 W	NTE 30Mbps
Total	250 kg	N/A	350 W	



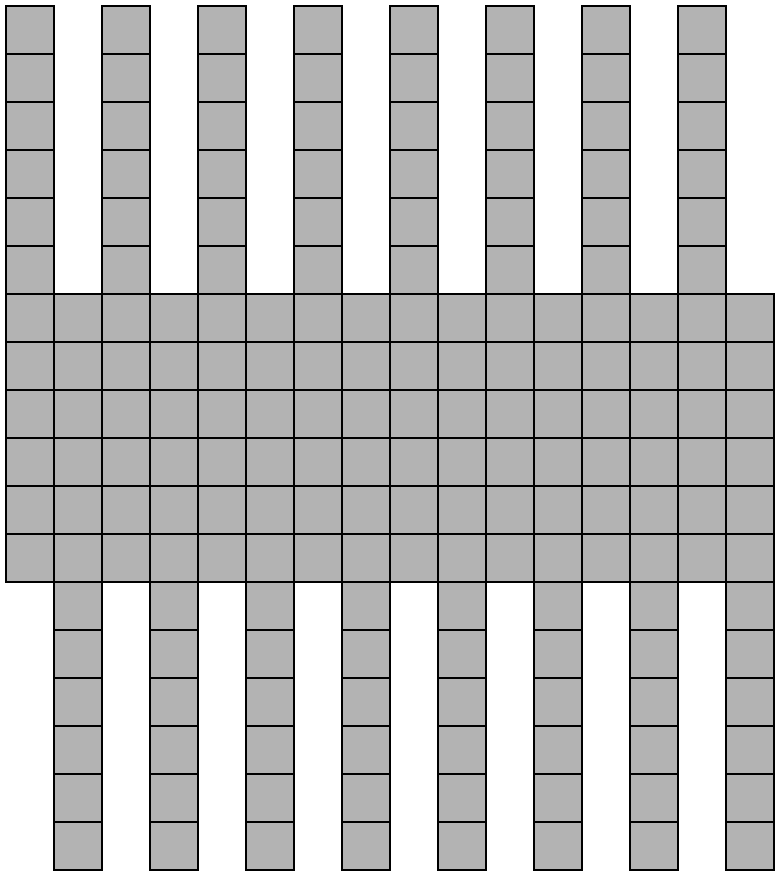
Possible Accommodation on NPOESS 2130 Spacecraft

Technical Issues

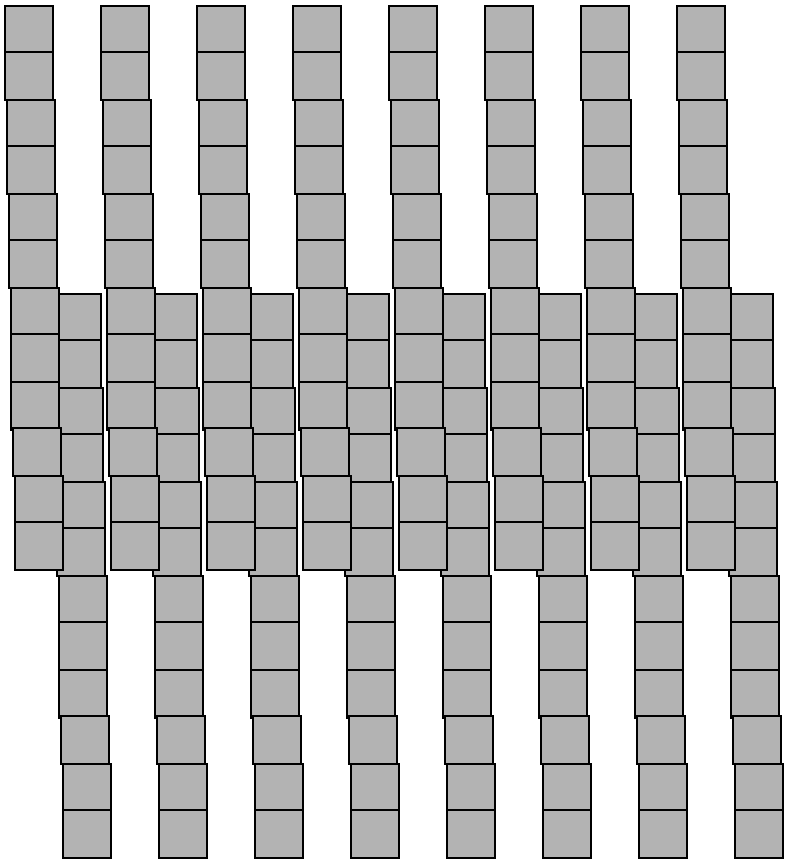
- **NPOESS Satellite Jitter & Stability Environment**
  - A Landsat sensor on an NPOESS satellite will require an isolation pallet to suppress jitter and linear acceleration
- **Lack of autonomous spacecraft yaw steering**
  - Pushbroom imagers (e.g., the ALI aboard EO-1) require yaw steering to maintain detector arrays orthogonal to ground track
  - The ALI focal plane design flown on an NPOESS satellite would produce image gaps up to 16 pixels wide
- **Pointing knowledge**
  - A Landsat sensor pallet might require its own attitude sensors (e.g., star trackers or gyros) to acquire sufficiently accurate pointing knowledge for accurate geographic registration
- **Fields of View - Location, Location, Location**
  - The available footprint for a Landsat sensor pallet limits the fields of view available for heat dissipation and for solar calibration

Pan Band Even/Odd Jitter

Nominal Pixel Pattern



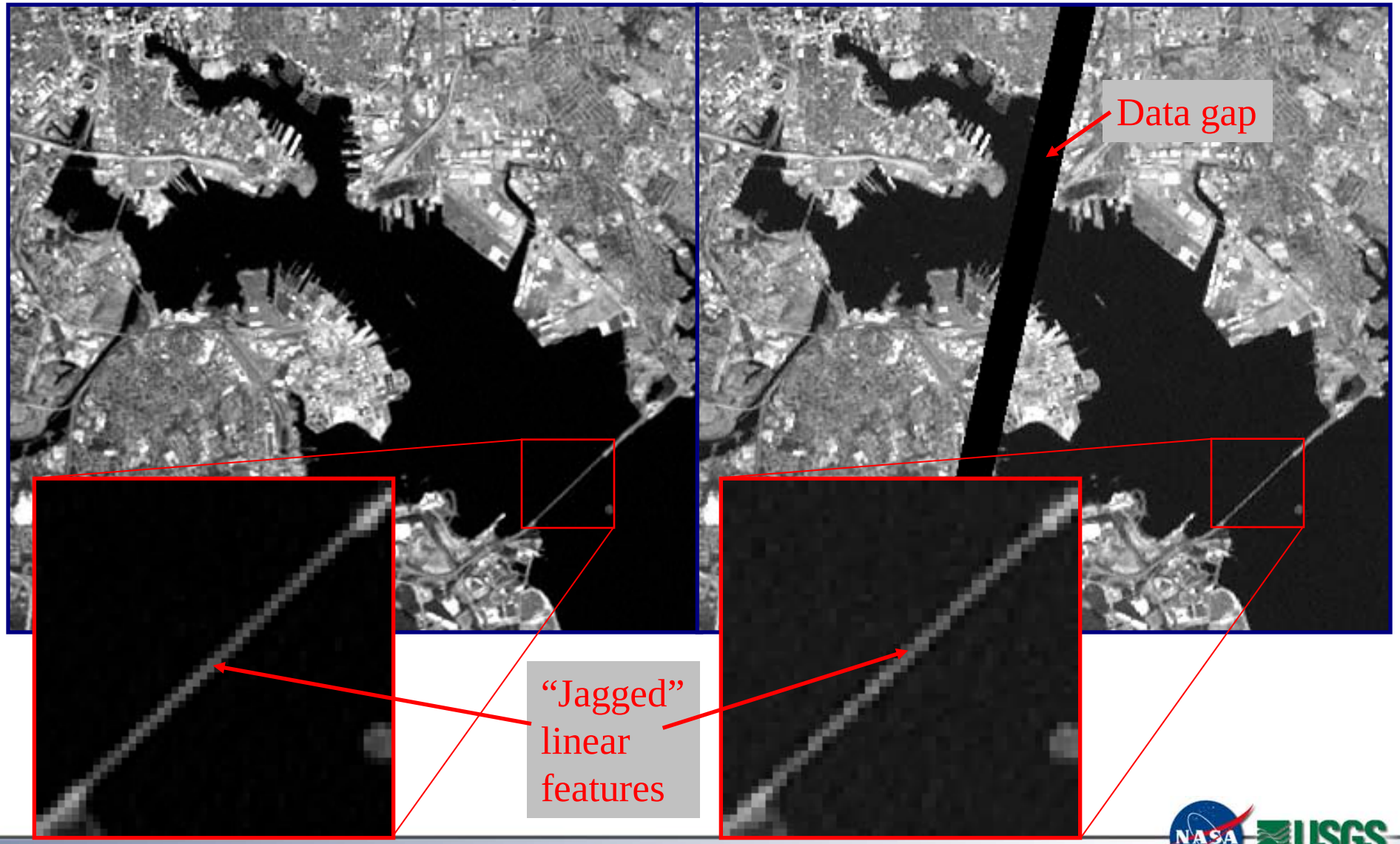
Jittered Pixel Pattern



ALI Band 7 Image of Baltimore

With Yaw Steering

Without Yaw Steering



NPOESS Program Schedule

LDCM

2002	A&O Contract Award
2005	NPOESS ΔPreliminary Design Review
2006	NPOESS Critical Design Review
2006	NPP Launch
2009	NPOESS Ground Readiness
2009	NPOESS C1 Launch
2011	NPOESS C2 Launch
2013	NPOESS C3 Launch
2015	NPOESS C4 Launch
2017	NPOESS C5 Launch
2019	End of Program

NPOESS Satellite Transition Schedule

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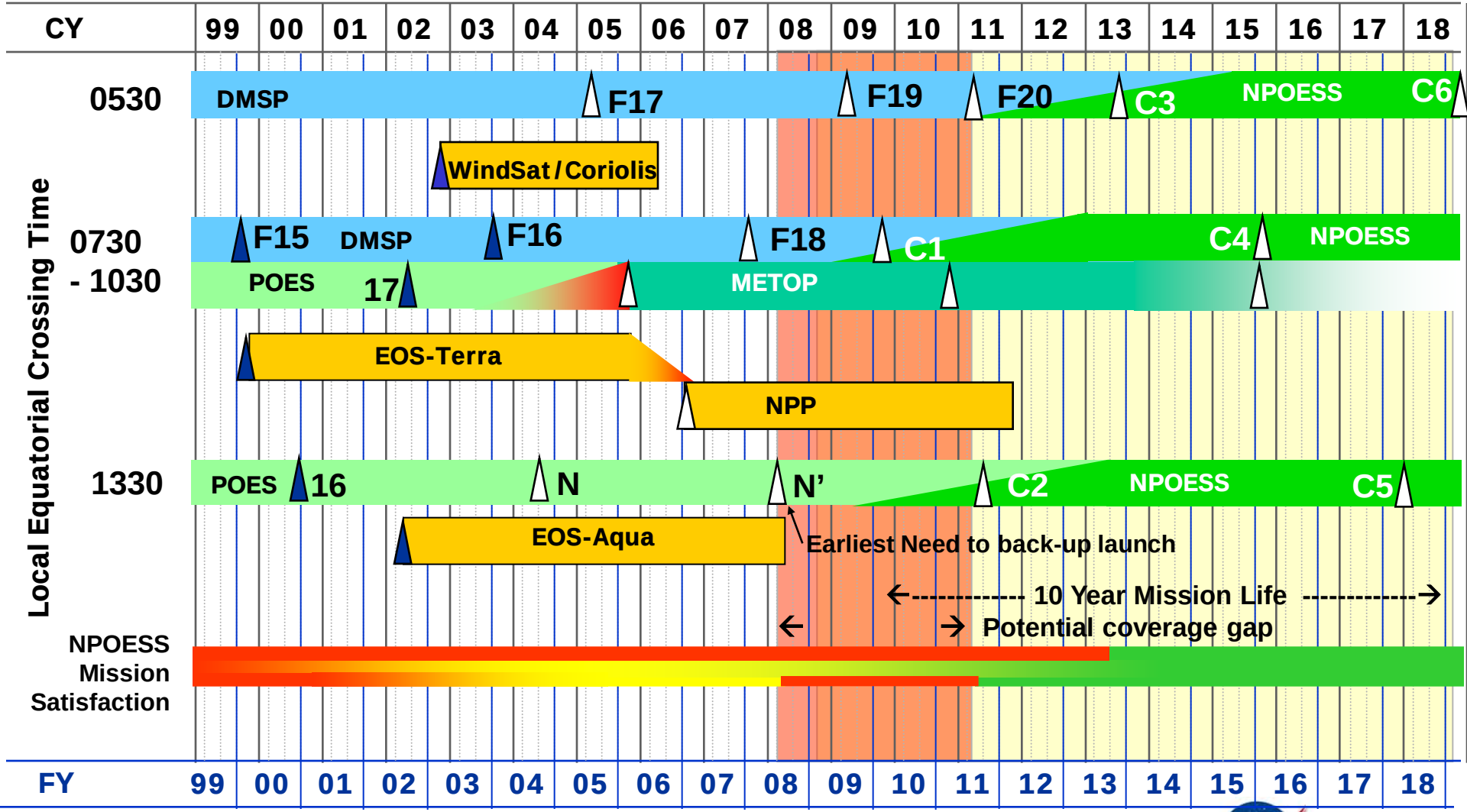
Slopes indicate 10-90% need



As of: 22 May 03

NASA USGS

Project Scientist's Concerns w/ NPOESS

LDCM

- **The 2130 NPOESS satellite may not launch in Dec., 2009**
  - The 2130 satellite is not necessarily the C1 satellite
  - Multi-instrument satellite systems are complex
- **The Landsat mission is secondary to the NPOESS mission**
  - No Environmental Data Records (EDR's) depend on Landsat data
  - The Landsat sensor was proposed as a P3I instrument to the EOP working group
- **Mitigating the technical issues may prove prohibitively expensive in terms of cost and schedule**
  - The time available to procure, develop, test, and deliver a fully capable sensor pallet for integration on the C1 satellite is already tight

Project Scientist's Concluding Remarks

- **We already have a partial Landsat data gap given the current limitations of the Landsat 7 and Landsat 5 satellites**
  - A complete gap appears likely in the next few years
- **The NPOESS satellites are less-than-ideal platforms for a high-resolution Landsat sensors**
  - The accommodation issues create technical, cost, and schedule risks
  - Programmatic issues (NPOESS schedules & priorities) increase the risk of further extending the Landsat data gap
- **A gap-filler mission (single sensor free-flyer) would reduce schedule and technical risks**
  - A gap-filler mission would allow us to address the accommodation issues in time for the NPOESS C4 launch
  - Current plans do not include a gap-filler mission

Back Up Charts

NPOESS Sensors

VIIRS	Visible / Infrared Imager / Radiometer Suite
CMIS	Conical Scanning Microwave Imager / Sounder
CrIS	Cross-track Infrared Sounder
ATMS	Advanced Technology Microwave Sounder
SESS	Space Environment Sensor Suite
GPSOS	GPS Occultation Sensor
OMPS	Ozone Mapping and Profiler Suite
ADCS	Advanced Data Collection System
SARSAT	Search and Rescue Satellite-Aided Tracking
APS	Aerosol Polarimetry Sensor
ERBS	Earth Radiation Budget Sensor
SS	Survivability Sensor
ALT	Radar Altimeter
TSIS	Total Solar Irradiance Sensor